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"Reinforced"

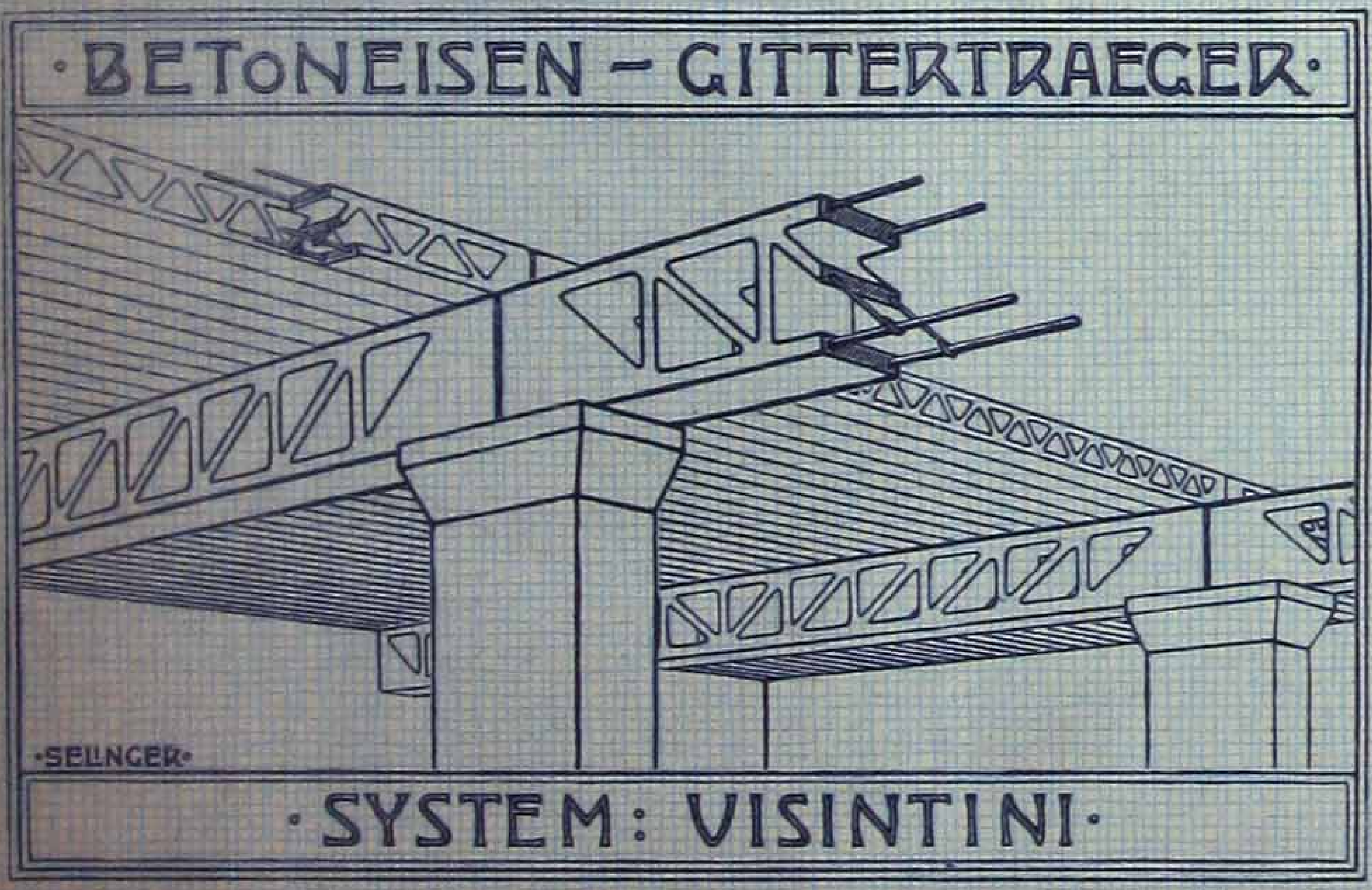
ARMED CONCRETE LATTICE-GIRDER

SYSTEM „VISINTINI“

BY MAX EMER, ENGINEER VIENNA

AND REPORT BY

Dr. ENG. FRITZ von EMPERGER, VIENNA



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Armed concrete lattice-girders.

Since the advantages of the so-called armed concrete constructions, i. e. have become known, numerous attempts have been made to secure maximum efficiency with a minimum expenditure of material and at a minimum cost of manufacture. A Zurich, Architect Mr. Franz Visintini has succeeded in designing armed concrete framework girders for building purposes, which combine all the above mentioned advantages.

As is well known, the advantages of a frame work girder are due to the favourable distribution of stresses which all act in the central plane of the members, and also to the fact that frame work girders require less material than solid ones, and are therefore considerably lighter. Visintini built up proper frame work girders of concrete, reinforced with iron bars the members subject to compression only, being made of concrete alone, while those always, or only with a certain distribution of load, subject to tension, are made of concrete with iron core. In upper and lower flanges or booms these cores are constituted by cylindrical rods to which the iron cores of the struts are connected simply by bending their ends round the cores of the flanges or booms. No sliding of the iron cores of the struts on those of the upper and lower flanges can take place, owing to the presence of the body of concrete enclosing them, so that concrete in this case replaces riveting.

As far as carrying capacity is concerned, there would be no necessity to provide members of compression booms whit iron cores, but it is preferable to do so, as this affords the simplest connection between struts and flanges.

In the first place, the inventor intends to apply his system of girders to building construction, and he designed various girders, beams and other parts used for building purposes, in such manner that they can be manufactured away from the building yard. This is a great advantage, as hitherto it was absolutely necessary to build up armed concrete

girders **in situ.** In this way, building operations are no longer delayed by the work of applying concrete, and the building yard no longer obstructed by centering and other boarding which was required hitherto. Visintini's armed concrete girders are cast in moulds to which the iron cores are secured. The illustrations below show girders manufactured in this way, and intended to be used as wallplates, girders, beams, etc., for floors, roofs, staircases etc.

When used for making floors, armed concrete girders are laid side by side, and the recesses filled with concrete. In order to prevent single girders from bending, wich would cause cracks in the plastering, the floor is made one whole in the following manner:

The upper flanges of each girder or beam are provided on both sides with longitudinal recesses of such shape as to produce, when two girders are placed side by side, a dove tail groove. Small pieces of iron are placed in this groove which thereupon is filled with mortar, and in this way ample security is obtained against longitudinal cracks in the ceiling.

Numerous tests as to the carrying capacity of such floors, made by the inventor, and in some larges cities in Europe, have given highly satisfactory results.

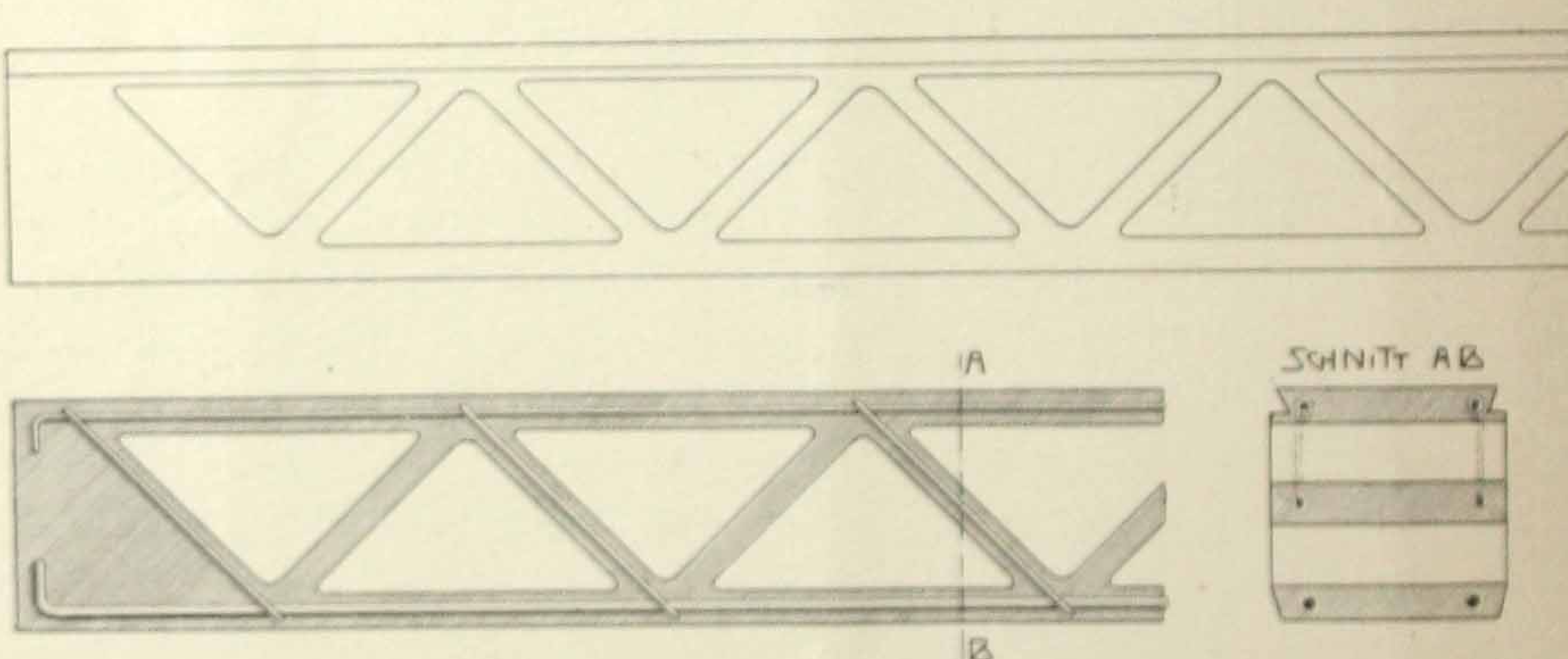


Fig. 1. Elevation, longitudinal and cross-section.

In case of cellars, larders etc., where the ceiling is not plastered, the separate girders need not be connected together, and it may be confidently expected that, like in other armed concrete structures which are generally distinguished by great rigidity, there will be verry little bending. Fig. 2 shows how the various kinds of flooring are to be secured to the finished support.

For laying a boarded floor, small wood blocks are placed in the dove tail grooves above referred to, before the mortar has set, the first set of boards being nailed to the said blocks and forming a support

for receiving flooring boards. The illustration shows clearly the method of laying a floor of tiles.

The spaces between the upper and the lower flanges and the struts of the girders form, in a completed ceiling, passages (of triangular cross-section) running transversely of the girders. These hollow spaces or passages containing air, prevent transmission of heat and cold and of sound through the ceiling.

Another advantage of this construction is that passages immediately adjoining the upper flanges, can be utilised as flues for heating the floor, thus obviating the drawback of having cold floors.

Another construction of floors with armed concrete girders consists in arranging them at certain uniform intervals apart and bridging over the intervals with auxiliary girders (also armed concrete lattice girders), as shown in Fig. 3.

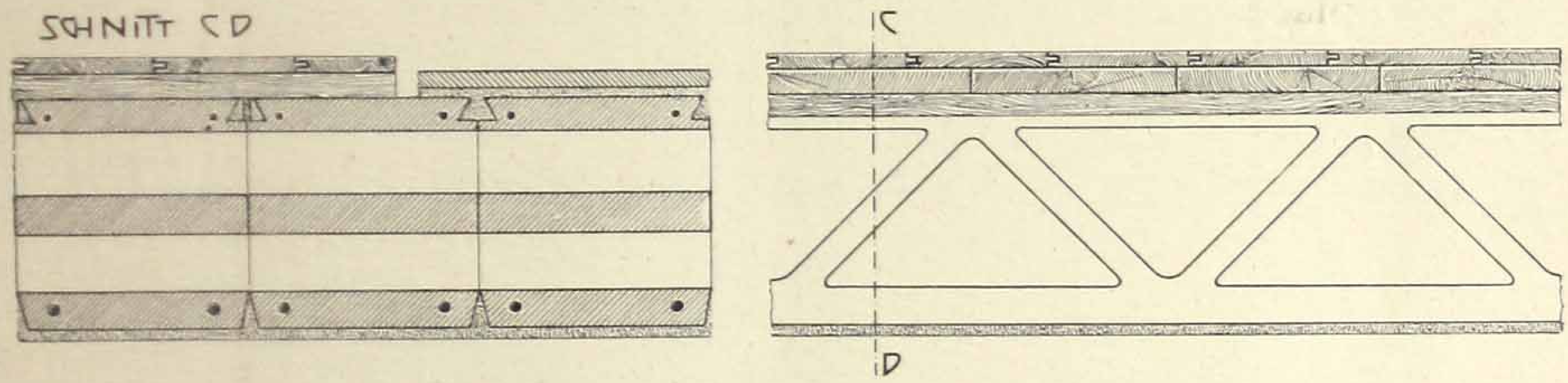


Fig. 2. Construction of the floor on a completed ceiling.

When armed concrete girders are to be used for making terraces or flat roofs, they are provided at one end with a drip and connected to form a roof in the way described, the roof being given a gentle slope in the longitudinal direction of the girders and rendered impermeable to water by means of a layer of asphalte. These girders afford a splendid material for construction of terraces or flat roofs, which is less affected by weather than any other material. Fig. 4 shows such a construction and at the same time illustrates the use of armed concrete girders as wall plates.

Armed concrete girders can also be used, singly as columns, or connected together to form a wall. These walls would also possess hollow passages or flues, to which applies what has been said with reference to the passages in floors. Fig. 5 shows clearly how openings for windows and doors are to be made in such walls.

In building staircases, the chief consideration, besides sufficient strength, is that they should be fire-proof. Unfortunately many so-called fire-proof staircases are in reality by no means so. An example of it is the favorite hanging staircase, consisting of steps let in at one end into the wall. A recent fire in Vienna has clearly shown that this construction is by no means fire-proof, as the staircase collapsed a few

minutes after the fire reached the stair well. Stone cracks under the influence of heat. The case is, however, different with structures of armed concrete. They have been proved to be thoroughly fire proof in the most conclusive manner by numerous experiments. Moreover, a staircase built of armed concrete is exceedingly light and elegant, as shown by the staircases actually constructed. Hitherto, however, the building of such staircases was not simple enough to induce architects to adopt them on a large scale. It is a point in favour of the new construction of staircases that the parts arrive at the building yard all complete, so that it is a comparatively simple matter to put them

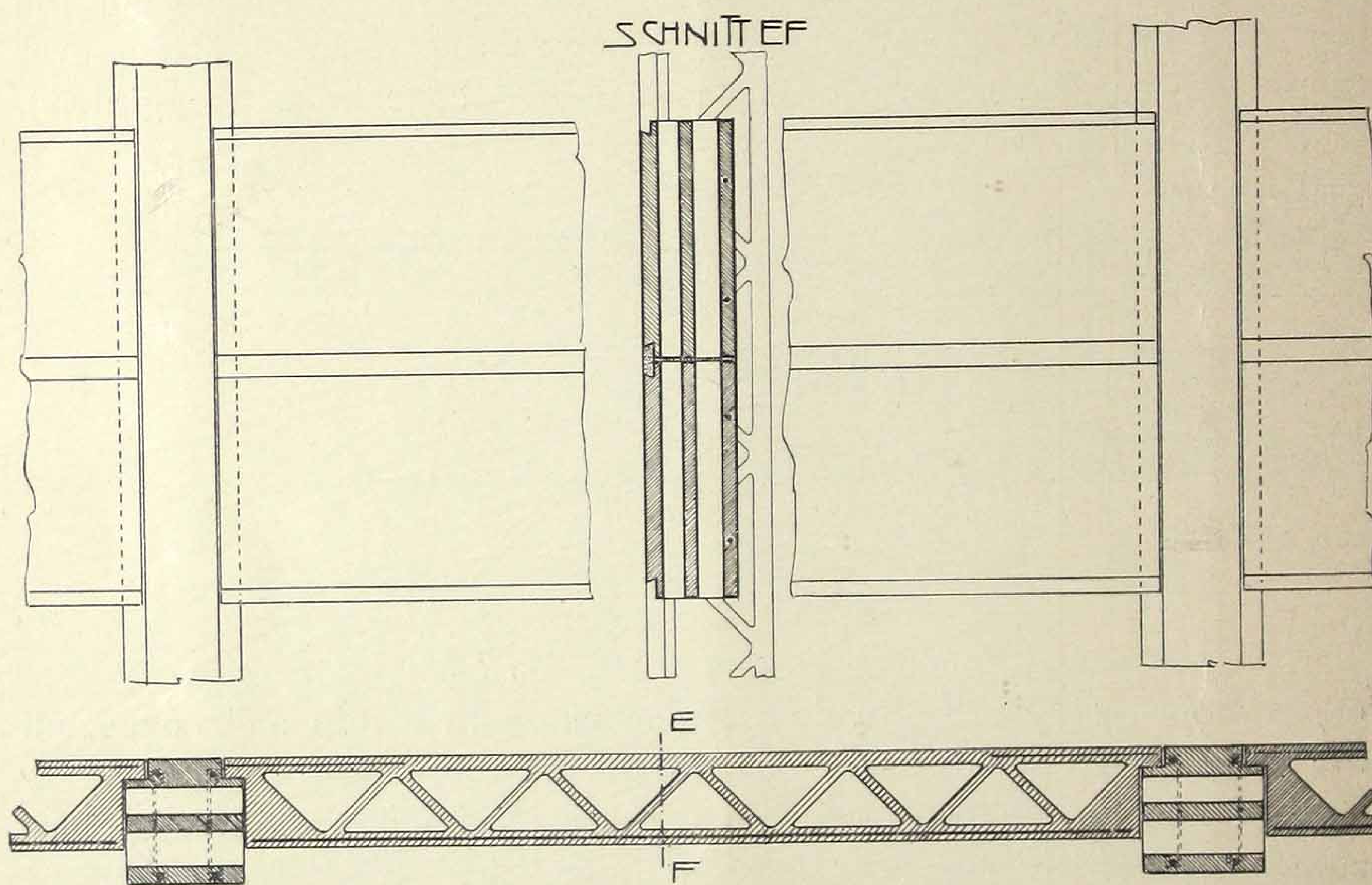


Fig. 3. Wall plates and filling girders.

together. The inventor has succeeded in designing armed concrete girders that combine all the above advantages.

A staircase built of armed concrete is clearly illustrated in Fig. 6. The riser is constituted by an armed concrete girder with a tread connected to the lower flange. The girder may be either supported at two points or be a cantilever, according as it is desired to have a supported or a hanging staircase. The illustration shows steps of a hanging staircase. The girder being a cantilever, is made fairly stout, but it could be made considerably lighter for supported staircases when it rests on two brackets. The illustration shows more clearly than any description could, the method of securing the tread to the girder constituting the riser, the iron cores of the said tread being in one piece with those of the vertical members of the girder. This simple

method of connecting the steps together is verry advantageous, especially as it compensates for any small irregularities in the manufacture or in erecting; this advantage is of special importance for the so-called geometrical stairs. The treads of the finished staircase are laid with some covering, and their front edges provided with a special ledge to prevent wear.

In hanging steps, the iron cores of the flanges can be extended

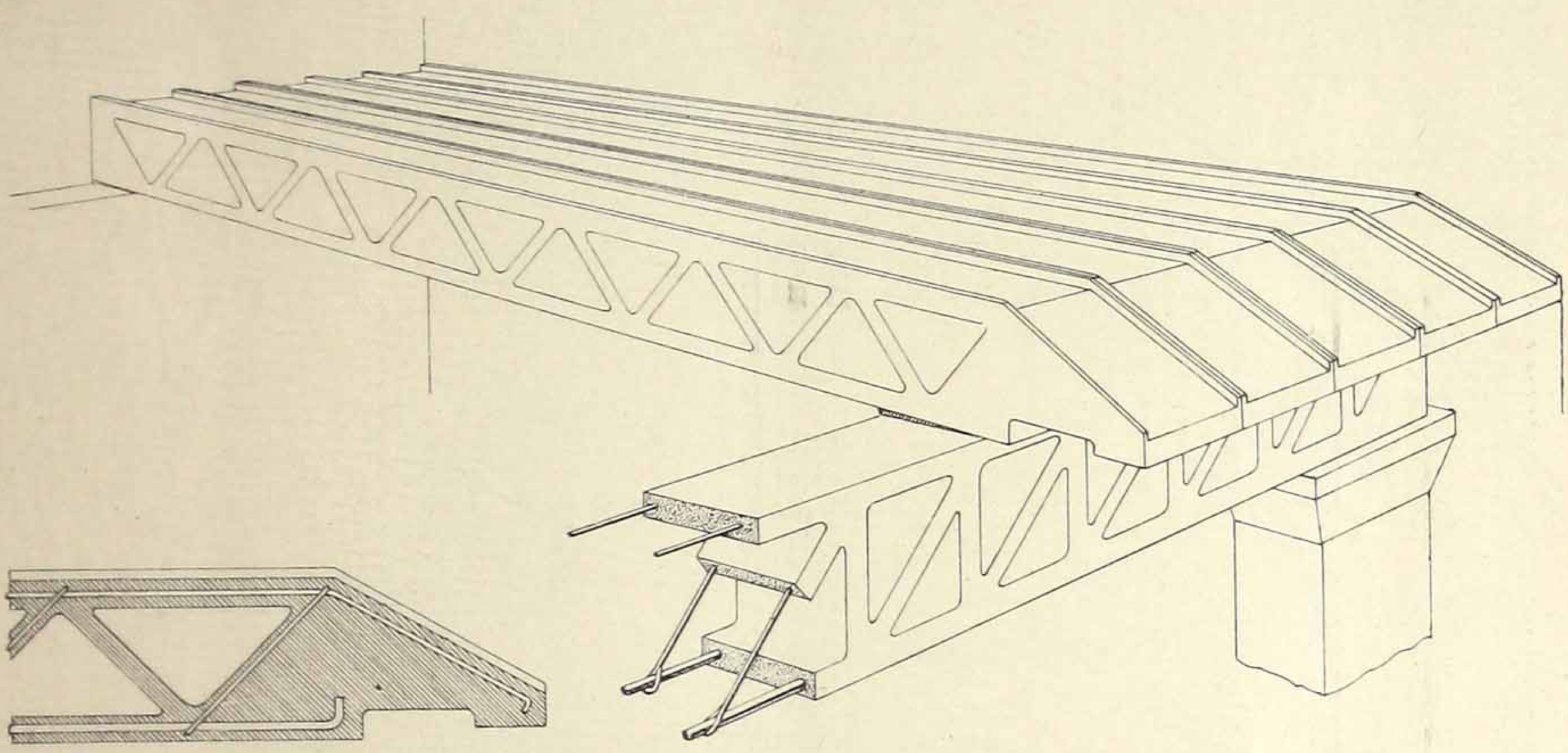


Fig. 4. Terrace girders.

to project beyond the free end of the steps, and utilised for securing the balustrade.

Although a staircase build of separate steps, is not quite so light as one of iron and concrete which is made in place from beginning to end and the arms of which are then also in one piece, our construction combines the advantages of stone staircases with that of being perfectly fire-proof; it is at the same time more reliable than a stone staircase, as the small tensile strength of the stone is here replaced by the great tensile strength of the iron cores.

The Visintini armed concrete girders possess, besides, the advantages inherent to all armed concrete girders, viz., **they are fire-proof, rigid and not liable to vibrations.** In order, finally, to help the reader to draw a definite conclusion, an extract from the opinion of the well known expert, Prof. Fritz von Emperger, may be given here.

Prof. von Emperger refers first to the question of organisation of building operations and says:

»The organisation of building operations obtaining at the present time, pre-supposes that all essential parts of the building, vertical walls excepted, have been made outside and delivered to the building yard.»

This organisation has led to the invention of several systems of building in concrete and iron which enable most parts to be supplied to the building yard in a more or less complete state. It may be interesting to quote here the salient points of the opinion, relating to such systems. It says as follows:

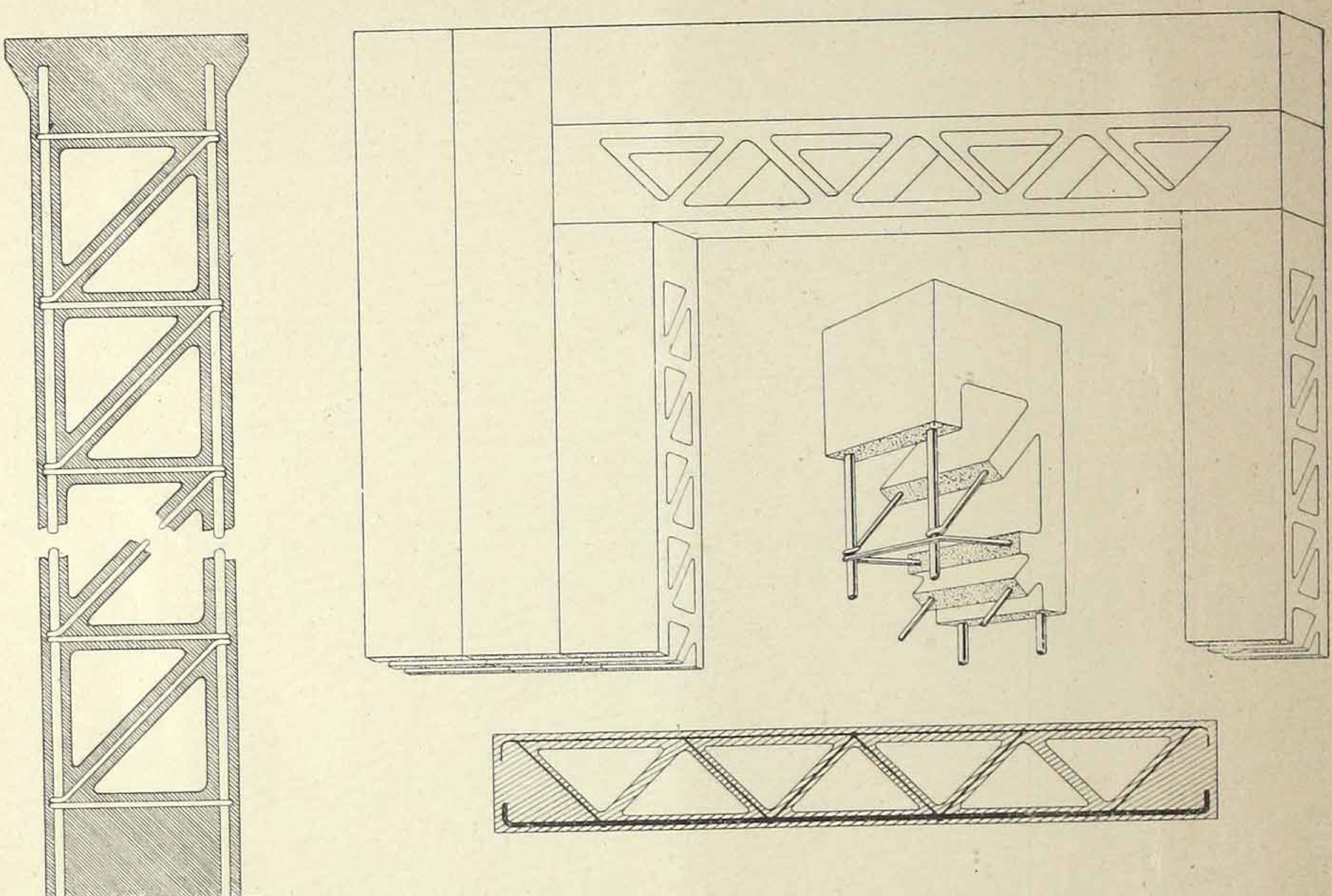


Fig. 5. Columns and their use.

»With reference to the above mentioned systems, the following may be said as a general proposition:

a) With reference to the general organisation of building operations, already touched upon:

1⁰ It is possible to test the parts delivered as to their quality and carrying capacity.

2⁰ When the necessary level is reached, the floor can be quickly made with the parts delivered, without the work of erecting the walls being interrupted.

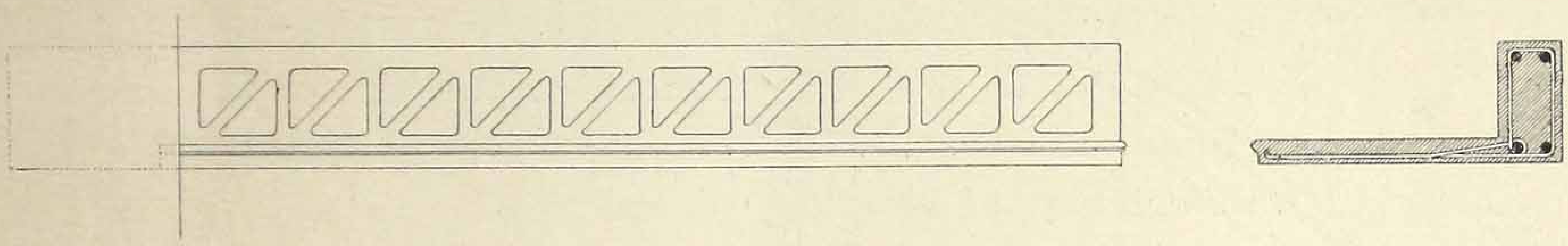
3⁰ Owing to the parts being supplied in a perfectly dry state, the floors can be used at once and without any scaffolding, and the work of the interior fitting procceded with.

b) With reference to the manufacture in a separate work.

4⁰ The parts are allways manufactured in the said works by experienced staff and under expert supervision.

5. By keeping concrete moist for a desired length of time, it can be given the properties which it never acquires when applied during the building, since it is impossible to keep it moist without rendering the building damp and since it is exposed to drafts and heat during the time of getting hard. This is of the greatest importance for the adhesion and efficient use of the iron.

6⁰ The girders are protected from injurious consequences of the setting of walls and of the premature removal of the



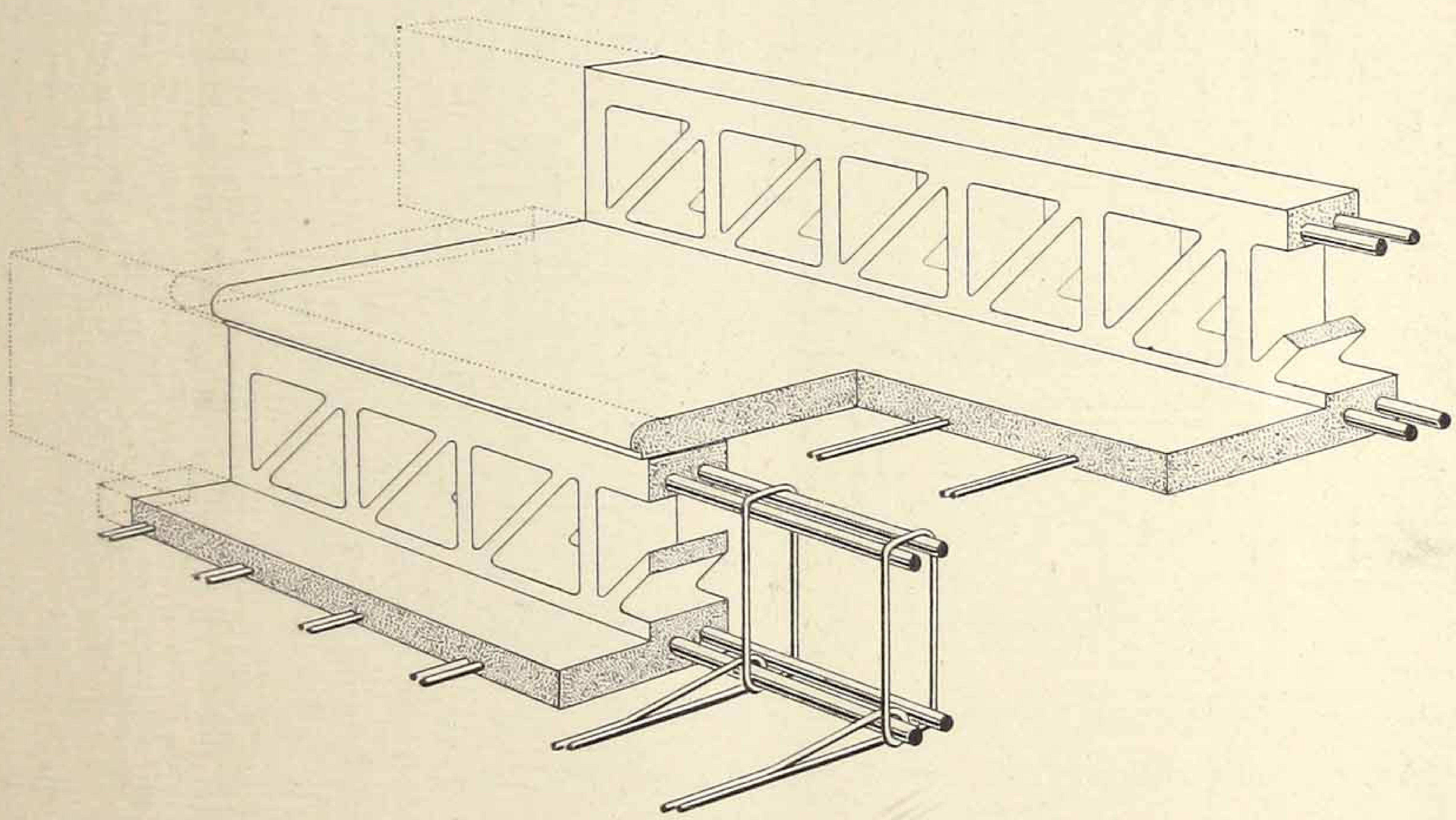


Fig. 6. Staircase steps.

boarding or centering etc., which are particularly dangerous in case of recently made concrete.

7⁰ The sand and gravel used are carefully chosen on the ground of long experience and from the kinds well known to the works.

8⁰ The same applies to the cement and to the proportions in which it is used, as well as to the testing of the necessary samples».

With reference to the **Visintini system** discussed in this pamphlet, the following advantages are mentioned in the opinion in question:

From the point of view of an architect:

1⁰ The air-flues produced by it in the floors, can be utilised as heating flues or as conduits for laying pipes and wires,

without the walls, or the decorations on them, being destroyed.

2° Prevention of cracks in the ceiling decoration.

3° Simplicity of renewal of damaged parts and facility of building annexes or extensions or making subsequent alterations.

With reference to the cheapness of manufacture:

4° Great simplicity of the mould, therefore small expenditure for installing a factory.

5° Possibility for installing the factory in proximity to the building yard, for the purpose of reducing the cost of carriage.

6° Convenience of handling in erecting.

7° The smallness of the quantity of mortar required for connecting Visintini armed concrete girders in such a way as to ensure their acting as one structure.

STATIC CALCULATION

by FRANZ VISINTINI, architect.

Let us assume that we have a girder section No. 18 of 5,00 m = 16′ 5″ span, diagrammatically shown in Fig. 7 and intended for making intermediate floors in a dwelling-house.

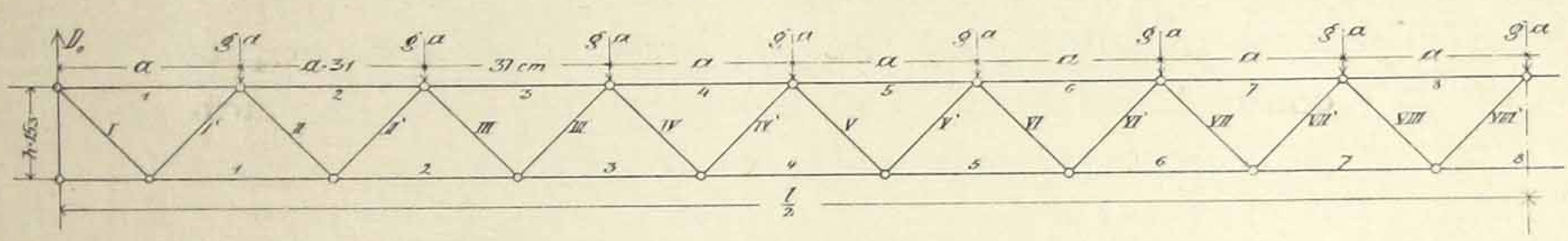


Fig. 7. Diagram of stresses.

Dimensions and Load.

Theoretical span = 496 cm. Distance between flanges h = 15,5 cm. Number of fields n = 16. Width of field a = 31 cm. The load due to the own weight 34 kg per meter run, the external load at 250 kg per m², 50 kg per meter run, therefore g = 84 kg per meter run.

Calculation of the frame-work.

For buildings it will be sufficiently near to assume that the total load composed by the own weight and the external weight is applied to the top flange. The moment of resistance is therefore calculated as follows.

Upper flange:

$$D_o = D_1 = (n - 1)\frac{ga}{2} \text{ Reaction of the abutment.}$$

$$\left.\begin{array}{ll} M = \dfrac{ga^2}{2}\left[(n+1)\left(m - \tfrac{1}{2}\right) - m^2\right] & \text{Moment of resistance} \\ X_m = -\dfrac{ga^2}{2h}\left[(n+1)\left(m - \tfrac{1}{2}\right) - m^2\right] & \text{Tension} \end{array}\right\} \text{ in the } m^{th} \text{ member.}$$

The upper flange being built up uniformly, it is only necessary to calculate the moment of resistance for the middle. Member, i. e. the M_{max}; in this case this would be the moment of resistance of the 8th member:

$$M_{mx} = \frac{84 \times 0{,}31^2}{2}\left[(16+1)\left(8 - \tfrac{1}{2}\right) - 64\right] = 25629 \text{ cmkg}$$

$$X_{mx} = \frac{M}{h} = \frac{25629}{15,5} = 1653 \text{ kg compression.}$$

Intensity of Stress.

The upper flange is dimensioned as follows: Width of a beam = 20 cm, thickness of the upper flange 2,5 cm. The upper flange has an iron core of 4 mm, therefore if $\alpha = 10$, $F = 20 \times 2,5 + 10 \times 0,1 = 51 \text{ cm}^2$.

$$\sigma_d = \frac{X_{max}}{F} = \frac{1653}{51} = 32 \text{ kg/cm}^2 \text{ compression in the concrete.}$$

Lower flange.

$$\left.\begin{array}{ll} M_1 = \frac{ga^2}{2} m\ (n - m) & \text{Moment of resistance.} \\ Z_m = \frac{ga^2}{2\ h} m\ (n - m) & \text{tension} \end{array}\right\} \text{in the } m^{th} \text{ member.}$$

$$Z_{max} = \frac{84 \times 0,31^2}{2 \times 0,155} \times 8\ (16 - 8) = 1666 \text{ kg tension.}$$

The iron alone has to take up the tension, therefore:

$$F_e = \frac{Z_{max}}{\sigma_e} = \frac{1666}{1000} = 1,666 \text{ cm}^2$$

If a 14 mm member is taken with $F = 1,5386$, then the stress on the iron will be

$$\sigma_z = \frac{1666}{1,5386} = 1082 \text{ kg/cm}^2$$

Calculation of the diagonals.

The angle of inclination $\alpha = 45^0$, β = therefore also 45^0. In the diagram, the tension diagonals are marked I, II, III and so on, whilst the compression diagonals I′, II′, III′ and so on. As the angle of inclination is 45^0 the same stress is acting on the tie-rod I as that on the strut I′, the same stress on the tie-rod II as on the strut II′, and so on.

Q_m is calculated for the m^{th} member, either descending or ascending to the right hand side, as follows:

$$Q_m = (n - 1)\ \frac{ga}{2} - (m - 1)\ ga = \frac{ga}{2}\ (n - 2\ m + 1)$$

The tension for the m^{th} member $Y_m = Y_m{}' = \frac{g\,a}{2 \cos \alpha} \times (n - 2\ m + 1)$

Tie-rods.

The rod exposed to the greatest stress is No. 1, therefore the first counted from the support $m = 1$

$$Y_1 = \frac{84 \times 0,31}{2 \times 0,707} \times (16 - 2 + 1) = 276 \text{ kg tension.}$$

$$F_e = \frac{Y_1}{\sigma_e} = \frac{276}{1000} = 0{,}276\ \text{cm}^2 = 1 \text{ member of } 6\ \text{mm}$$

$$\text{Tie-rod II } Y_2 = \frac{84 \times 0{,}31}{2 \times 0{,}707} \times (16 - 4 + 1) = 239\ \text{kg tension}$$

$$F_e = \frac{239}{1000} = 0{,}239\ \text{cm}^2 = 1 \text{ member of } 6\ \text{mm}$$

$$\text{Tie-rod III } Y_3 = \frac{84 \times 0{,}31}{2 \times 0{,}707} \times (16 - 6 + 1) = 202\ \text{kg tension}$$

$$F_e = \frac{202}{1000} = 0{,}2\ \text{cm}^2 = 1 \text{ member of } 5\ \text{mm.}$$

Struts.

The strut subject to the greatest stress is No. I′, that is the first strut counted from the point of support, rising towards the centre. The compression is equal to the tension on the member I, that is 239 kg. The struts are 1,5 cm thick, 20 cm wide, therefore one $F = 1{,}5 \times 20 = 30\ \text{cm}^2$.

$$\sigma_d = \frac{239}{30} = 7{,}9\ \text{kgcm}^2$$

It is obvious from the above that compression in the member subjected to the greatest stress, is 7,9 kg per cm². This is far below the safe load, and as the members nearer the centre are exposed to a steadily decreasing stress, further calculation is unnecessary.

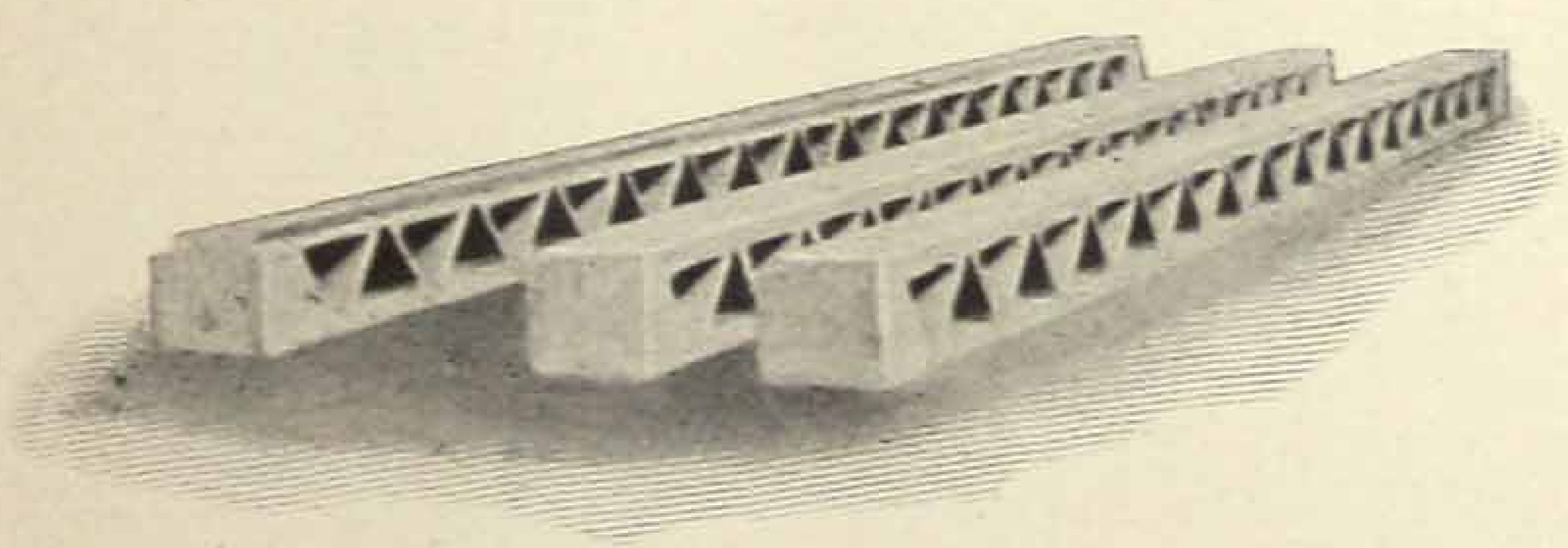


Table of the armed concrete lattice-girders of the „Visintini"-System.

Calculated for a load of 250 kg per m^2, with a safety factor equal to 10 for the concrete and 4 for the iron.

Dimensions											Maximum moment of resistance		Maximum stress				Stresses					
											Mmax.		Xmax.	Zmax.			in the tension rib. From the point of support				Compression Diagonal	
Section No. Depth	Width of the girder	Upper flange	Lower flange	Diagonals	Span	Height between the centres of gravity of the iron cores h	Distance between apices a	Number of fields n	Own weight per meter run	Own weight + load g	Upper flange	Lower flange	Upper flange	Lower flange	Cross-section of the concrete of upper flange + 4 iron core of 4 mm	Iron core in the lower flange	1.	2.	3.	4.	1.	Cross-section of the compression diagonal
in cm					m	cm			kg		in cmkg		in kg		cm^2	mm	in kg					cm^2
15	20	2,5	2,5	1,5	2,00	12,5	25	8	33	83	3875	4150	321	332	51	7	102	73	44	14	102	30
15	20	2,5	2,5	1,5	2,50	12,5	25	10	33	83	6354	6484	508	518	51	8	132	102	73	44	132	30
15	20	2,5	2,5	1,5	3,00	12,5	25	12	33	83	9208	9337	736	747	51	9	161	132	102	73	161	30
15	20	2,5	2,5	1,5	3,50	12,5	25	14	33	83	12579	12709	1006	1016	51	11	190	161	132	102	190	30
18	20	2,5	2,5	1,5	3,72	15,5	31	12	34	84	14328	14530	924	937	51	10	202	165	128	92	202	30
18	20	2,5	2,5	1,5	4,03	15,5	31	13	34	84	16952	16952	1093	1093	51	11	220	184	149	110	220	30
18	20	2,5	2,5	1,5	4,34	15,5	31	14	34	84	19575	19777	1263	1276	51	12	239	202	165	128	239	30
18	20	2,5	2,5	1,5	4,65	15,5	31	15	34	84	22602	22602	1458	1458	51	13	257	220	184	149	257	30
18	20	2,5	2,5	1,5	4,96	15,5	31	16	34	84	25629	25831	1653	1666	51	14	276	239	202	165	276	30
21	20	3,0	3,0	2,0	5,04	18	36	14	39	89	27970	28260	1554	1570	61	14	293	248	203	158	293	40
21	20	3,0	3,0	2,0	5,40	18	36	15	39	89	32296	32296	1794	1794	61	15	316	271	226	203	316	40
21	20	3,5	3,0	2,0	5,68	17,75	35,5	16	41	91	36411	36698	2051	2067	71	16	342	296	250	205	342	40
21	20	3,5	3,0	2,0	6,035	17,75	35,5	17	41	91	41285	41285	2325	2325	71	17	364	319	273	228	364	40

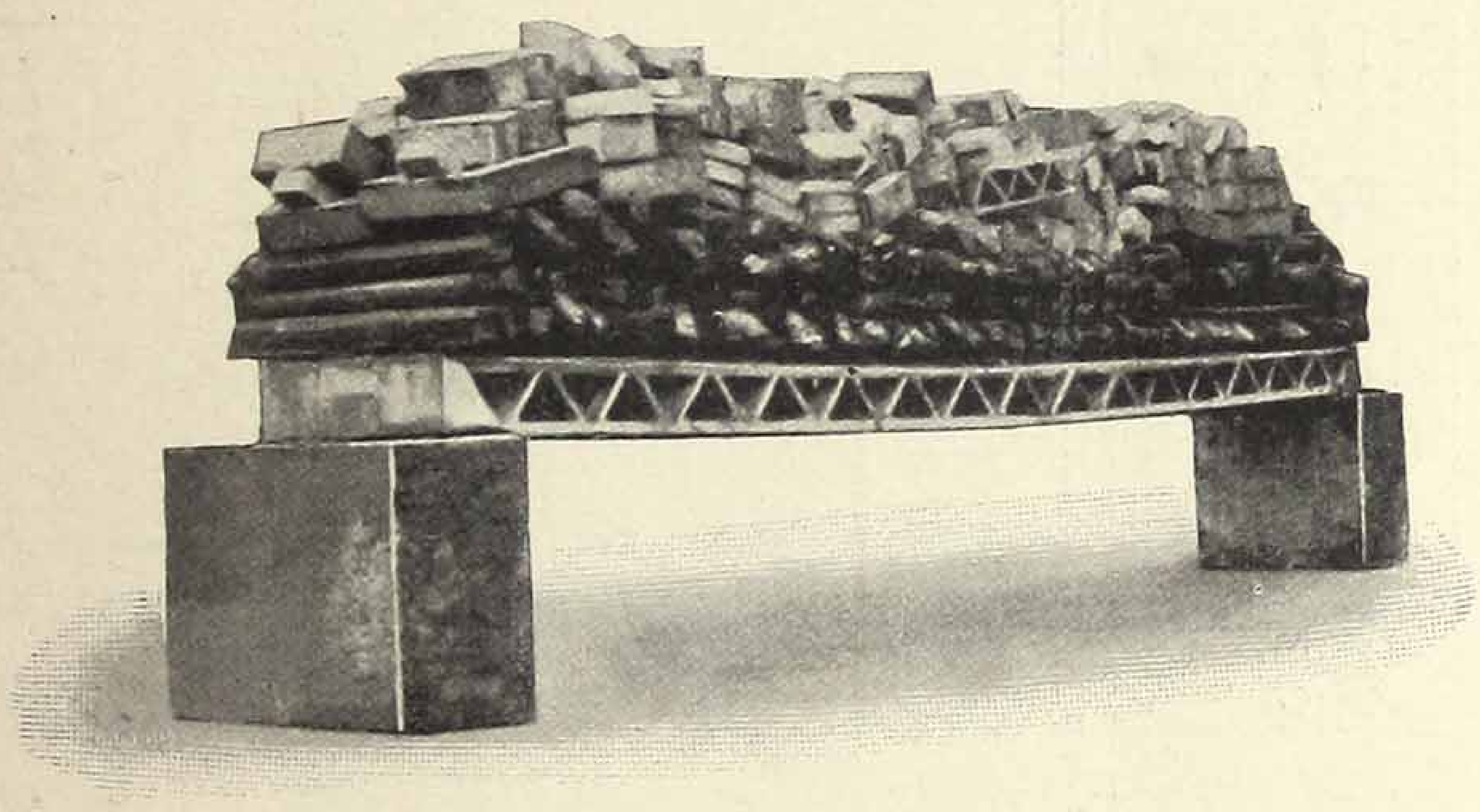
Certificate of test

carried out by the Building-Office of the City of Zurich

concerning the

safe load

on a floor made of armed concrete lattice-girders of the „Visintini-System“.



Photograph taken during gradual bending until complete rupture. Breaking Load 9706 kg.

A. Construction.

Resting on 2 brickwalls of about 90 cm height three armed concrete lattice-girders were laid side by side. The construction of the girders may be seen in the above cut.

The joints between the girders were filles with the mortar of the following composition: 1 part by volume of cement + 1 part of sharp sand.

The girders had been made 9 weeks previously to the tests, and the construction of the floor was commenced on May 1st, 1903.

The tests were carried out on the May 12th, 1903.

B. Manner in which the test was carried out.

In order to obtain uniform distribution of the load, the floor was covered with a layer of sand about 3 cm deep.

Then pig iron bars, weight of which previously has been determined, were piled up in as uniform manner as possible. The number of pig iron bars at disposal being insufficient, blocks of cement were used to increase the load.

The extent of deflection of the floor was recorded at regular intervals of time by means of a lever of a leverage of 1 : 10.

C. Result of tests.

Length 620 cm. Free Length 600 cm. Width 60 cm. Depth 21 cm.

Load in kg	Deflection in mm	Remarks
565	0 50	
1042	1 00	
1529	2.00	
2019	4 50	
2506	7,25	
3026	9 50	
3450	12,00	
	12 50	10 minutes later.
127	2,00	All the load taken off the floor, except the lager of Sand (127 kg).
	1 50	
3450	13 00	The load put on again.
4025	14,50	The apparatus of Mantel shows an extension of the lower flange of 0,16 mm.
4540	16,25	
5085	19,25	
5630	21,50	
6165	24,00	
6676	25,50	
7139	27,00	
7484	28,50	
7894	30,25	
8451	33,25	
9021	36,50	
9706		Slow and steady bending until rupture in the centre (see sketch page 15).

Zurich, May 12 th, 1903

(Seal of the Building-Office of the City of Zurich.)

The City-Architect:
A. Geiser.

Test at Vienna

by the Building office of the City of Vienna

represented by Mr. HARTL, engineer

on the 25th of May 1903.

5 Girders 8″ wide laid side by side, each reinforced by two $^5/_8$″ round iron bars in the lower flanges and the tension strutts reinforced by $^3/_{16}$″ round iron rods, 45 days old.

Span 20′ — Width 3′ 4″ — Depth 9$^3/_8$″ — Upper flange 1$^6/_{16}$″ — Lower flange 1$^3/_{16}$″ — Strutts 1″ — Own weigth 500 lb.

Load kg/m²	Load Total kg	Deflection mm
268	1584	1,6
0	0	0,6
268	1584	1,7
535	3168	3,7
803	4752	5,7
1071 1)	6336 3)	7,9 5)
1339	7920	10,5
1607	9504	13,0
1874	11088	15,9
2142	12672	18,3
2410	14256	21,7 6)
2460 2)	14553 4)	—

In the lower flange fine crack in the middle.

English measure:

1) 1071 a square meter = 2 cwt a square foot.
2) 2460 a square meter = 4 cwt 2 qr 2 lbs a square foot.
3) 6336 kg = 6 tons 6 cwt 2 qr 14 lbs.
4) 14553 kg = 14 tons 10 cwt 3 qr 17 lbs.
5) 7,9 mm = $^5/_{16}$″.
6) 21,7 mm = $^7/_8$″.

Test at Berlin

by the govermental testing-station

(königl. mechan.-techn. Versuchsanstalt in Charlottenburg.)

The dimensions are the same as those of the tested floor at Vienna. There were 3 floors tested in the same manner. When a load of nearly

11 tons was put on the 3. floor, the load was taken off again to see the permanent deflection.

The girders were 9 weeks old:

1. test		2. test		3. test	
Load kg	Deflection mm	Load kg	Deflection mm	Load kg	Deflection mm
4810	5	3700	4	2710	2
7960 [1])	10 [7])	7540 [3])	11 [7])	7320 [5])	12 [7])
14830	30	15990	35	10870	20
17310	37	18010	41 [8])	The load is taken off.	
18340	42 [8])	19080 [4])	—	Permanent deflection = 1 mm	
19350 [2])	—	rupture		2760	3
rupture				7330	13
				15070	28
				17080	40 [8])
				18720 [6])	—
				rupture	

In all three cases the floor was slow and steady bending until rupture.

English measure:

1) 7960 kg = 7 tons 18 cwt 3 qr 19 lbs = 2 cwt 2 qr a square foot.
2) 19350 kg = 19 tons 6 cwt 3 qr 17 lbs = 6 cwt a square foot.
3) 7540 kg = 7 tons 11 cwt = 2 cwt 1 qr 7 lbs a square foot.
4) 19080 kg = 19 tons 1 cwt 1 qr = 5 cwt 3 qr 19 lbs a square foot.
5) 7320 kg = 7 tons 6 cwt 1 qr 7 lbs = 2 cwt 1 qr a square foot.
6) 18720 kg = 18 tons 14 cwt 1 qr = 5 cwt 3 qr.
7) 10 mm = $^{3}/_{8}$".
8) 42 mm = $1^{5}/_{8}$".